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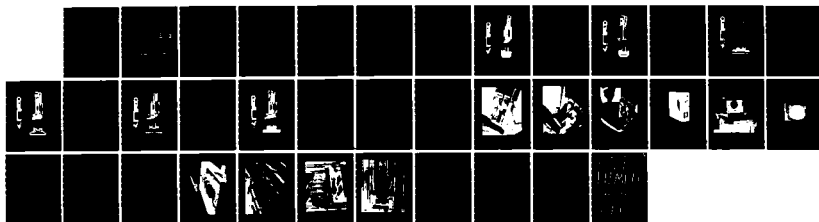
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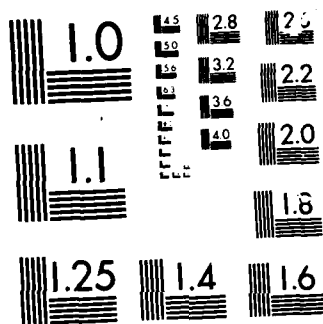
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TECHNICAL REPORT ARFSD-TR-85004

COPPERHEAD CONTAINER LATCH

PAUL J. LACARRUBBA

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| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br><br>An improved version of the container latch for the Copperhead M712 projectile is now available. It can be grasped with more comfort, provides the tightest seal possible, and has good shock resistance. Detailed illustrations describe its development. Computer graphics show competing latches under shock load. |                                     |  |

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## INTRODUCTION

An alternate version of the latch for the Copperhead M712 projectile container has been designed and tested. The new latch differs from the old one primarily because it can be grasped with more comfort for easier opening.

The new latch provides the tightest seal possible with the least opening pull force for a T-bolt mechanism of this type. It has at least as much shock resistance as the former latch and possibly more. The new version can retrofit the existing container and is adaptable to existing production tooling at minimal cost.

The latch is intended to be opened in the field, with bare hands or gloves, under combat situations. When damage to the container makes manual operation difficult, the latch can be pried open by a simple tool such as a screwdriver. Opening the container more quickly can expedite fire power under certain circumstances. When sudden change of mission is ordered, the rounds are still in the containers, and the soldier must pull on a number of latches before he pulls the lanyard.

An illustration of how the new latch differs from the old one is given in figures 1 through 6 in which photos are arranged in the chronological order in which the latch evolved. Manual operation by two individuals of different physical build is illustrated in figures 7 through 9.

Preliminary shock tests at ARDC demonstrated that the latch will remain closed under any jolt anticipated in transportation. An environmental test conducted at White Sands Missile Range on two containers randomly selected from production revealed no leaks along the gaskets after vibrations, drops, and shocks.

## DESCRIPTION

### **Camlock Latch (fig. 1)**

With the inception of the Copperhead projectile, a field-worthy container was needed. Lanson Industries, a recognized supplier of missile containers, originated a clamshell type design. The keystone of any clam shell is its latch, and after a careful study, Lanson chose what was then known as the Camlock. At that time the only supplier of this style latch was Rexnord in Hasbrouck Heights, New Jersey, which had absorbed the original Camlock firm. This latch was relatively cheap and had been used extensively by the Air Force and the Navy. Lanson based their first Copperhead container around this latch. The system's contractor, Martin Marietta Aerospace, qualified the container for the M712 projectile.

An over-center type latch is a bolt which fastens the lid to the trunk. The end of the bolt has a nut or hook and seats on an accessory of the lid known as



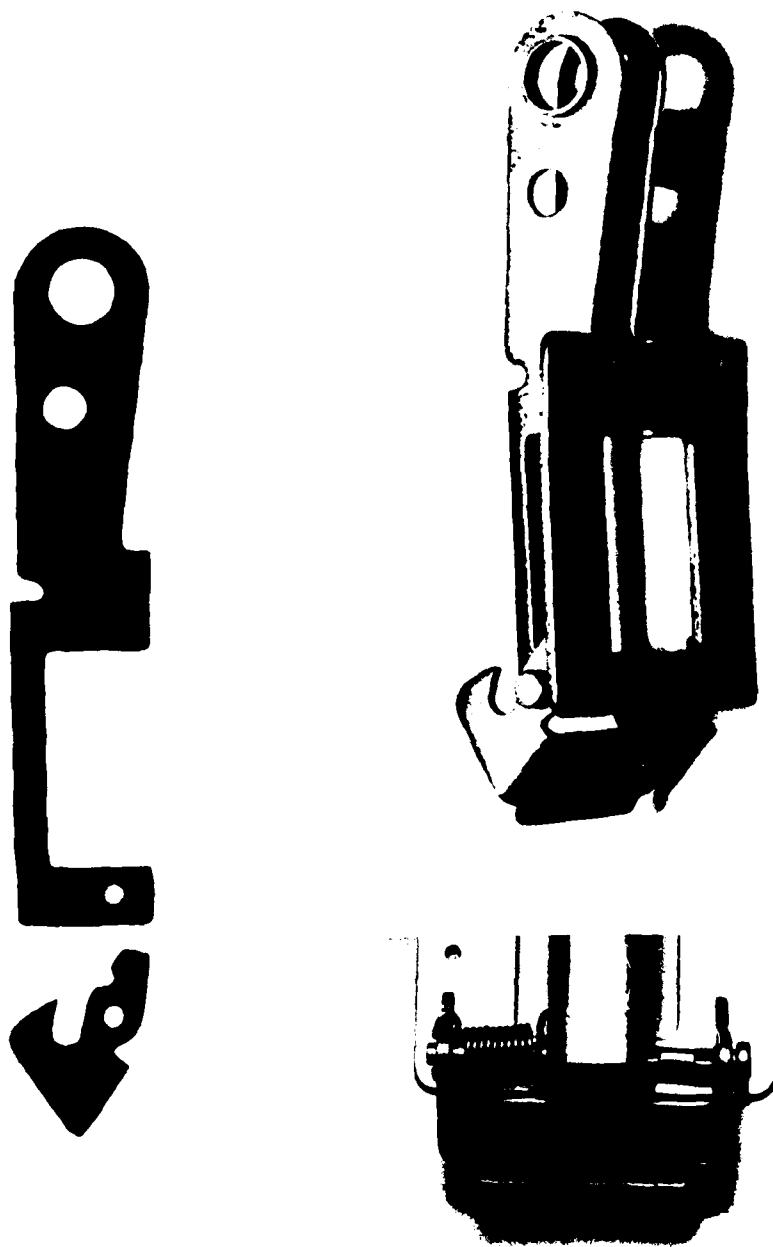


Figure 1. Camlock latch

the strike or keeper. The head of the bolt does not seat directly on the trunk but is linked to an accessory known as the cage. When the link is pointing away from the lid, the bolt is at maximum tension. The link is not stable in this position because the tension in the bolt can rotate it in either of two directions. When securing the latch, the link is rotated beyond the point of maximum tension by an amount known as the toggle angle. The tension in the bolt then presses the link against the trunk or against an accessory fixed to the trunk such as a plate. To further secure the link, spring loaded hooks can grab the edge of the plate. This set of hooks is often referred to as the secondary lock.

The Camlock was normally supplied with its own cage plate and striker. These pieces were tailored to engage the lock and nest the barrel nut properly. Lanson had integrated these parts into their container weldment, resulting in excessive toggle. The over-center hump which the handle had to swing through was too severe.

After 30 containers were manufactured, it was discovered that a latch tight enough to compress the rubber gasket and seal the container was also difficult to open. Containers that had passed the pressurized leak test required as much as 70 lb of pull to release the handle, depending upon the unlatching sequence. These were not true field containers because tools were needed to open them.

#### **Baseline Latch (fig. 2)**

The Camlock latch (fig. 1), originally selected for the Copperhead container, was difficult to open. Lanson Industries discovered the problem early in production.

To expedite round deliveries, the government allowed Lanson to modify the handle. The circular hole which pivots the T-bolt was changed to a slot. When the latch was closed, the clevis pin was seated on the outboard end of the slot. This reduced the over-center resistance that the handle had to rotate through thereby reducing the force necessary to pull the latch handle open. When the handle was swung open, the pin would fall to the bottom of the slot. The washer and cotter pin cleared the irregular aluminum extrusion where the handle pivoted.

Containers equipped with these latches could be sealed with pulls around 25 lb. This lower force was due to the slotted hole; however, Lanson maintained good flatness on the flanges of the clamshell halves which also kept the opening force down. Nevertheless, there were practical limitations on tolerances for a weldment this size. The baseline was realistic and allowed Lanson to go as high as 50 lb to seal the container.

The human interface of the depot-styled latch was still not optimized for the field environment anticipated by the Army. The device could only be grasped with two fingers, and a tool to pry it open might not be handy. Yet the container could not be changed. A substantial investment had already been made to qualify the projectile around its vibration profile. The only solution remaining was to further modify the latch within the framework of existing tooling.

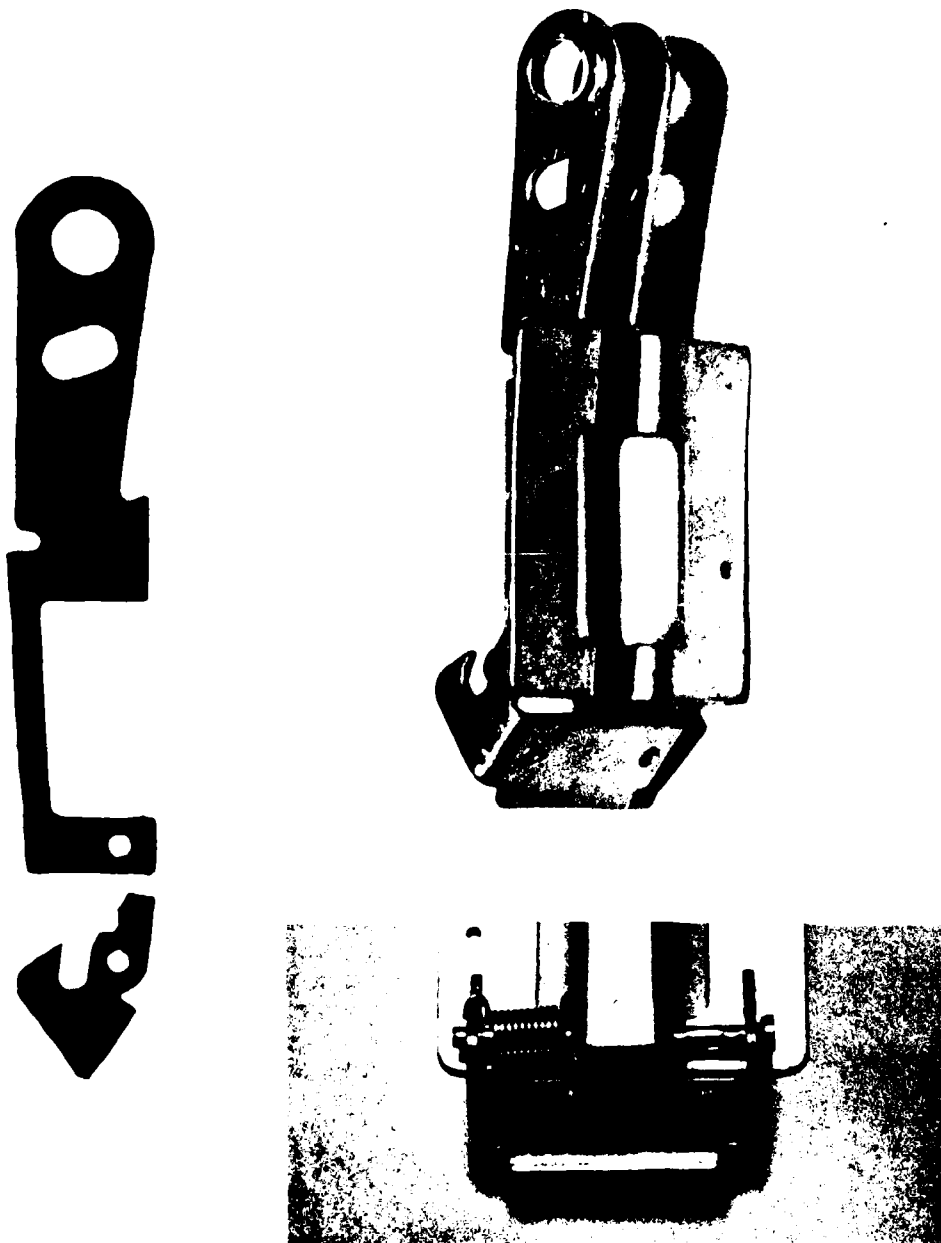


Figure 2. Baseline latch

### **Heavy Gripper Plate (fig. 3)**

The drawbacks of the baseline latch were eliminated with the assistance of Ancra Corporation in El Segundo, California; however, the improvements were not all inclusive.

The slotted holes, which cut across most of the width of the handle, were eliminated. The round hole was resurrected and relocated for an easy over-center movement of the handle. This placement also eliminated interference of the clevis pin and its washer and cotter pin with the weldment of the latch cage.

The round hole in the handle worked quite well. At least four containers on Lanson's assembly line were equipped with this latch and passed the leak test with pull forces that averaged 24 lb. The prototypes were then removed and the leak test repeated on the same containers with the baseline latches. The average pull force for the production latch was 25 lb.

The design for the wider grip was fairly straightforward. No tooling changes to the dies for the lock were required. Modifications from secondary operations on the formed part were used instead. Two holes in the lock face, originally intended as forming guides, were reamed larger and a wide steel plate was riveted through them. Calculations indicated that the additional mass of the plate might cause the lock to unhook following a mild jolt. In fuze terminology the plate could act as a g-weight. To compensate for the added weight, the single spring was replaced by two springs, each ten times stiffer than the original.

This prototype failed the preliminary shock test. The gripper plate was too heavy to be restrained, even by stiffer springs. Furthermore, the shape of the lock hooks was found to affect shock vulnerability.

The pop-open threshold for this latch depended on its position in the cage which varied considerably because the Ancra lock had much wider hooks than the Rexnord. These hooks engage an aluminum plate in the cage weldment. Play in this engagement was found to be undesirable relative to shock resistance. If the cage plate contacted the stems or shanks of the hooks, the handle could swing outward following the shock. It appears that a second impact of the teeth of the hooks against the cage plate was causing the lock to bounce or slide off. This conclusion is not intended as a criticism of the Ancra design. Their lock was designed for a particular cage and was never meant to be weighted and shocked to this extent.

### **Stamped Gripper Plate (fig. 4)**

The stamped latch used the same Ancra handle (fig. 3) that performed well at Lanson's leak test station. This part was mated to the shock resisting Rexnord lock of the baseline latch and backed up with the stiff dual springs. The heavy gripper plate (fig. 3) was replaced by a formed sheet of 0.040 inch-thick mild

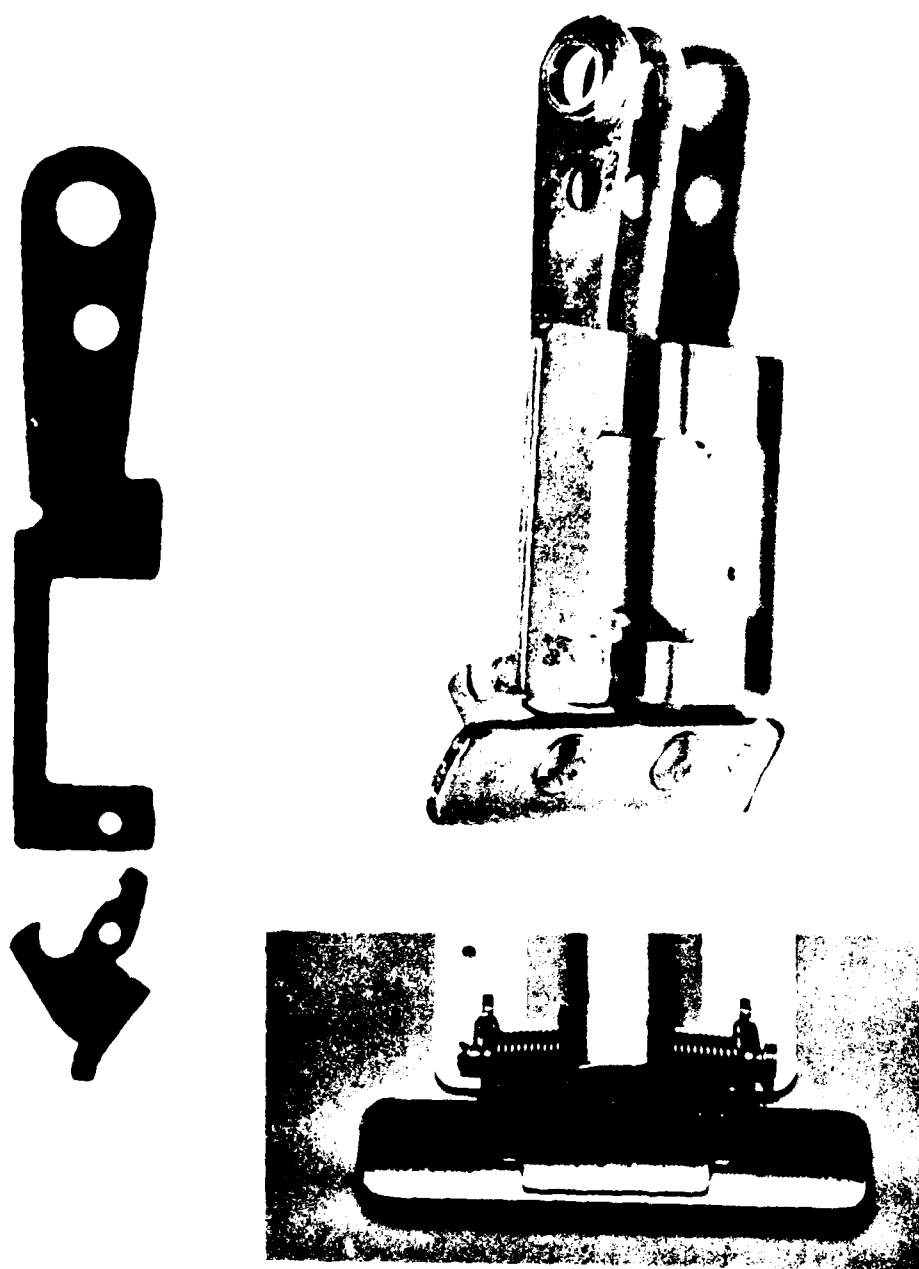


Figure 3. Heavy gripper plate

steel. The boat shape of this grip combined lightness, strength, and comfort, and was attached to the lock with simulated tubular rivets. The rivets could easily support 100 lb when applied to the spherical ends of the boat.

After the design was reviewed, Ancra suggested another alternative: a lock and grip made from a single blank. Dies for this combination could be made for the same investment as tooling for the boat-shaped grip. Furthermore, if such an integral design were practical, the secondary operation of riveting would be eliminated.

#### **Improved Latch (fig. 5)**

The final prototype version was developed by ARDC and the Ancra Corporation. The retrofit is completely interchangeable with the baseline latch and requires no other modification to the Copperhead container.

The lock and grip are integral and can be made from a single set of progressive dies. The lock has two ears that fit inside the channel of the container with ample clearance. Sufficient space remains around the grip so that a gloved hand can slide below it. Most individuals can get four fingers on the ears. When damage to the container makes manual operation difficult, a screwdriver can be inserted behind an ear and the latch pried open using the edge of the channel as a fulcrum.

The slots which form the hooks are slightly narrower than the baseline latch furnished by Rexnord. This feature improves shock resistance. The slots angled for optimum meshing with the cage plate, have sufficient width and depth to compensate for normal variation in the cage weldments.

The new lock is heavier than the baseline lock and its greater moment amplifies jolts. However, a pair of stiff springs retain it, and calculations show that this combination is as shock resistant as the old design.

The pin which hinges the lock can bend if the lock is pried. A gentle arc will not interfere with operation, as has been demonstrated over the years with the baseline latch. The improved latch has a slightly thicker and harder pin.

The holes which hinge the T-bolt are round for least bearing resistance. They provide the optimum over-center angle combining easiest opening for tightest seal. There is a limitation on the diameter of the washer that accompanies the clevis pin, but otherwise, there is no interference with the weldment over the full swing of the handle. Either a clevis pin or drive pin can be used, depending upon preferences during assembly or field maintenance.

#### **Plastic Coated Grip (fig. 6)**

The ears of the latch can be coated with a rubbery, widely used thermoplastic material. This versatile composition of polyvinyl chloride is not new and

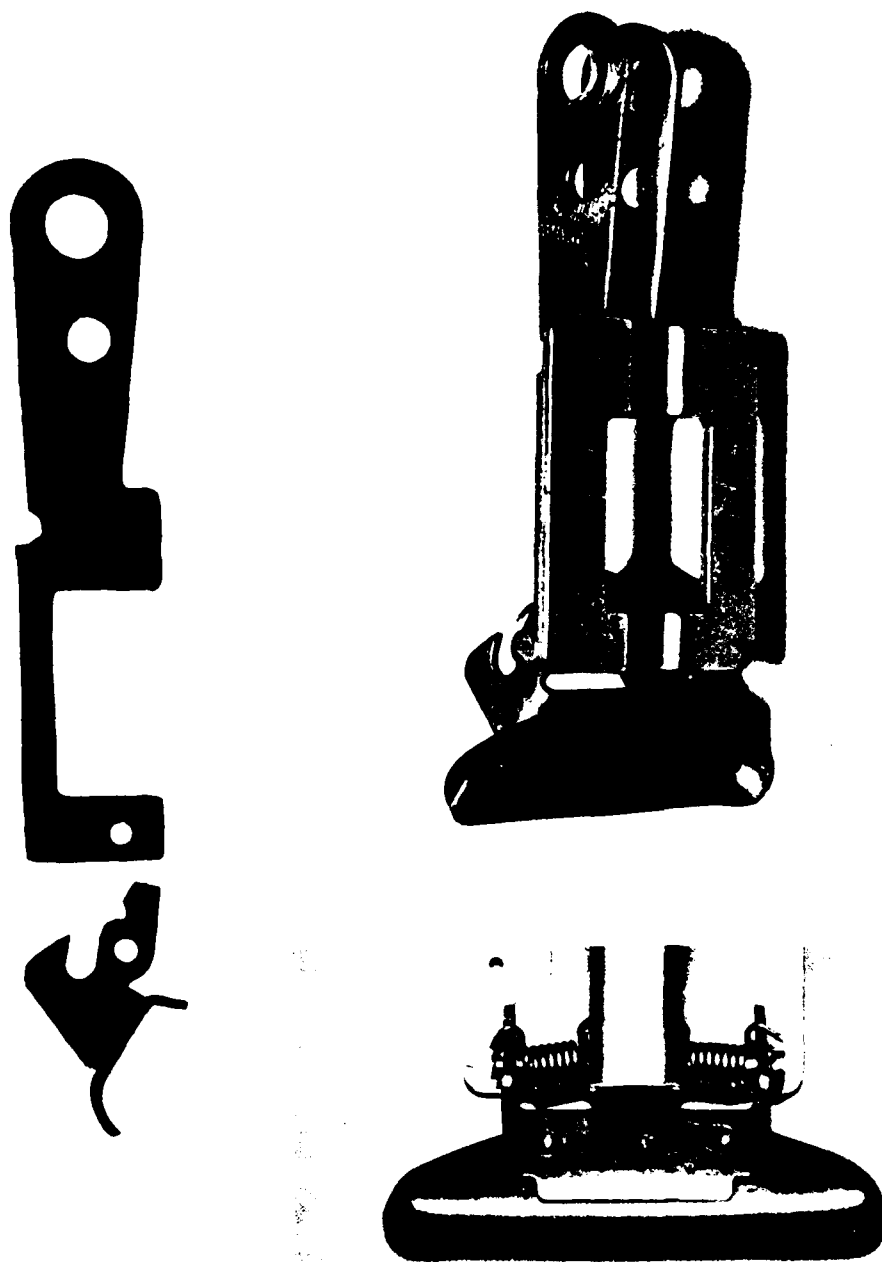


Figure 4. Stamped gripper plate

dates back to 1931 when early development was done in Germany. The paste was a mixture of vinyl resin and plasticizers that would gel into a flexible solid when heated. During that decade the manufacture of fabric coatings spread throughout Europe, and by 1949 the Americans had coined the name plastisol.<sup>1</sup>

The metal part to be coated is heated to 350°F, lacquered, dried, and then dipped in liquid vinyl while still hot. The thickness of the coating is governed by the rate of withdrawal.<sup>2</sup> Most of the vinyl beads on the lower edge of the grip; this area is just where the cushion is needed. Coloration of green or black is available.

## TEST PROGRAM

### Preliminary Shock Test

A major concern of any change to the container is that the modification might cause the loss of the seal which keeps the projectile dry. The latch must remain closed if the container is dropped. A preliminary shock test was performed on all prototypes investigated in order to preclude a lengthy test program on a latch that would pop open when it should not.

The shock machine for this test had limited capacity and could not hold a complete container. The sawed-off bulkhead (fig. 10), which included two latch cages, was bolted to the shock platform of figure 11. The bulkhead was mounted on its side so that the shock pulse would be in the direction of opening the latch located on the lower face. The fixture provided enough space around each latch to allow it to swing open.

Copperhead requirements dictate that the container shall remain sealed following an impact of 200 g's for 10 ms, three times, on each of its six faces. The highest shock pulse within the capacity of the machine was 250 g's for 7 ms (fig 12).

Two factors in the test fixture that influenced the opening g thresholds of all the latches shocked were the particular bulkhead selected and the opening pull force of the latch.

The cage plate (or latch base) varied in length from one bulkhead to another. These plates do not extend down far enough to fully engage the lock hooks. Lanson Industries welds these plates on a fixture using locking pliers. Dimensions can vary from one cage to another by as much as 0.040 inch.

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<sup>1</sup> Lloyd R. Whittington, "A Survey of Literature and Patents Pertaining to Vinyl Plastisol Technology and Rotational Casting," Small Creative Printing, Ashland, Ohio, 1961, p 13.

<sup>2</sup> StanChem Incorporated, Coatings and Polymers, East Berlin, Connecticut 06023.



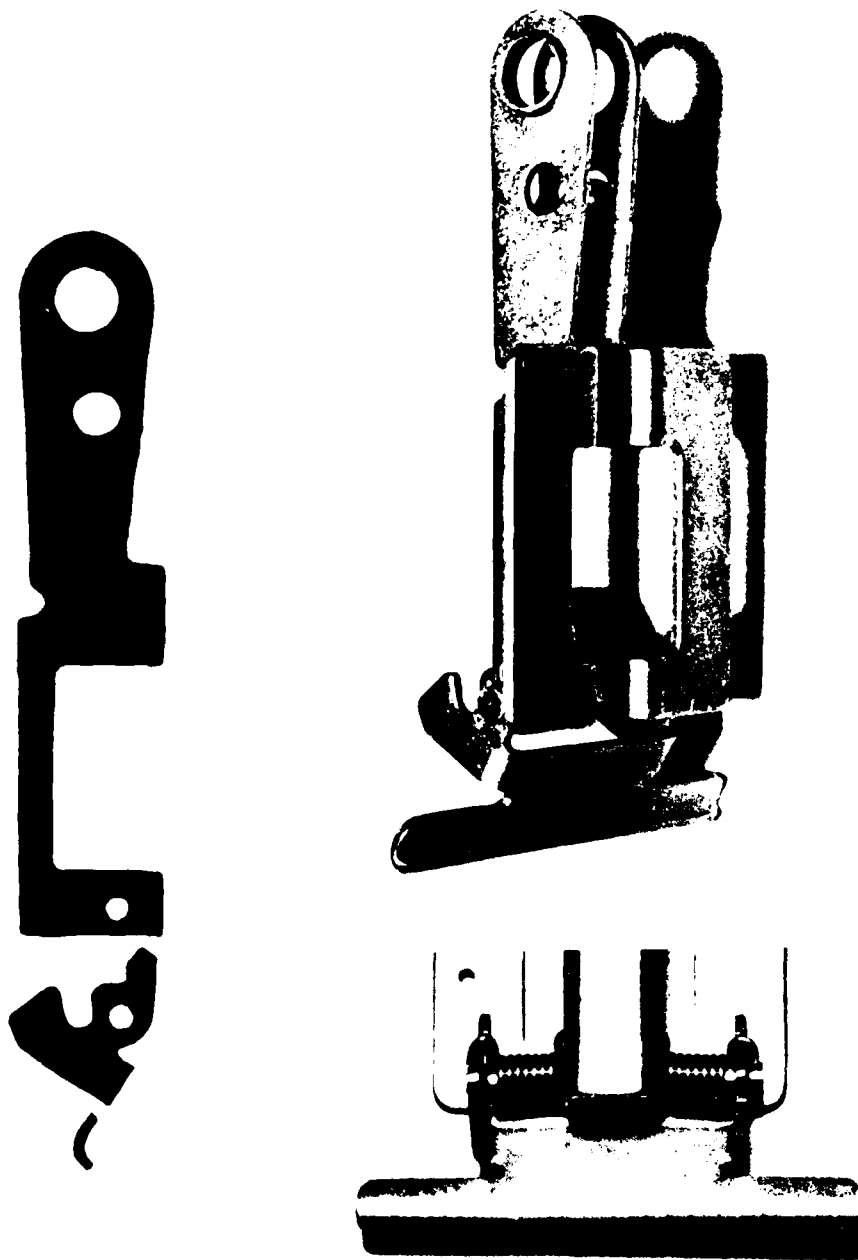


Figure 5. Improved latch

The tension in the T-bolt also affects the number of g's necessary to jar the latch open. This toggle force, which holds the latch handle closed, is difficult to adjust. The barrel nut on the T-bolt can only be rotated by increments of one half turn.

A latch cage was selected to compare the thresholds of each design. Each latch was mounted in the cage, adjusted to an opening pull force of from 7 to 8 lb, and then shocked. The pull force necessary to open each latch was determined by hooking a spring scale to its lock.

The baseline latch (fig. 2) was shocked inside the test cage after having been adjusted to 8 lb. It remained closed up to 145 g's.

The improved latch (fig. 5) and the latch with the plastisol grip (fig. 6) were tested in the same cage and at the same pull force as the baseline latch. Both remained closed up to the shock limit of the machine. The two dual spring latches were then modified. The lock pin was partially slipped out from each handle, one spring was removed, and the pin was reinserted to restore the assembly. The single spring version of the improved latch remained closed up to 195 g's. The single spring version of the latch with the plastisol grip remained closed up to 180 g's.

The latch with the stamped gripper plate (fig. 4) remained closed up to the shock limit of the machine.

The prototype of the heavy gripper plate (fig. 3) was adjusted to a pull force of less than 5 lb. It had two opening g thresholds, depending upon its initial position in the cage. If the closed latch were pulled outboard so as to contact the teeth of the hooks, then 170 g's for 7 ms were necessary to open it. If the closed latch were pushed inboard so as to contact the stems or shanks of the hooks, then only 70 g's for 8 ms opened it. In the latter case, it is likely that the handle moved in the direction of setback causing the lock to glance off the cage plate. It was concluded that the wide hooks of this prototype contributed to its vulnerability to shock.

The graphic simulations of figures 13 through 15 illustrate locks under shock.

A latch specifically designed for screwdriver operation (not shown) was also shock tested on the bulkhead. Its handle was similar to the Camlock, except that the lower end was formed into a tube where a rod may be inserted. There was no lock or spring. The latch opened at only 80 g's when the pull force was adjusted to 9 lb; but remained closed at 240 g's when the pull force was adjusted to 16 lb. This is a good example of how T-bolt tension increases shock resistance.

Based upon the encouraging "no open" result of the improved latches (figs. 5 and 6) a comprehensive test program was undertaken on the dual spring versions.

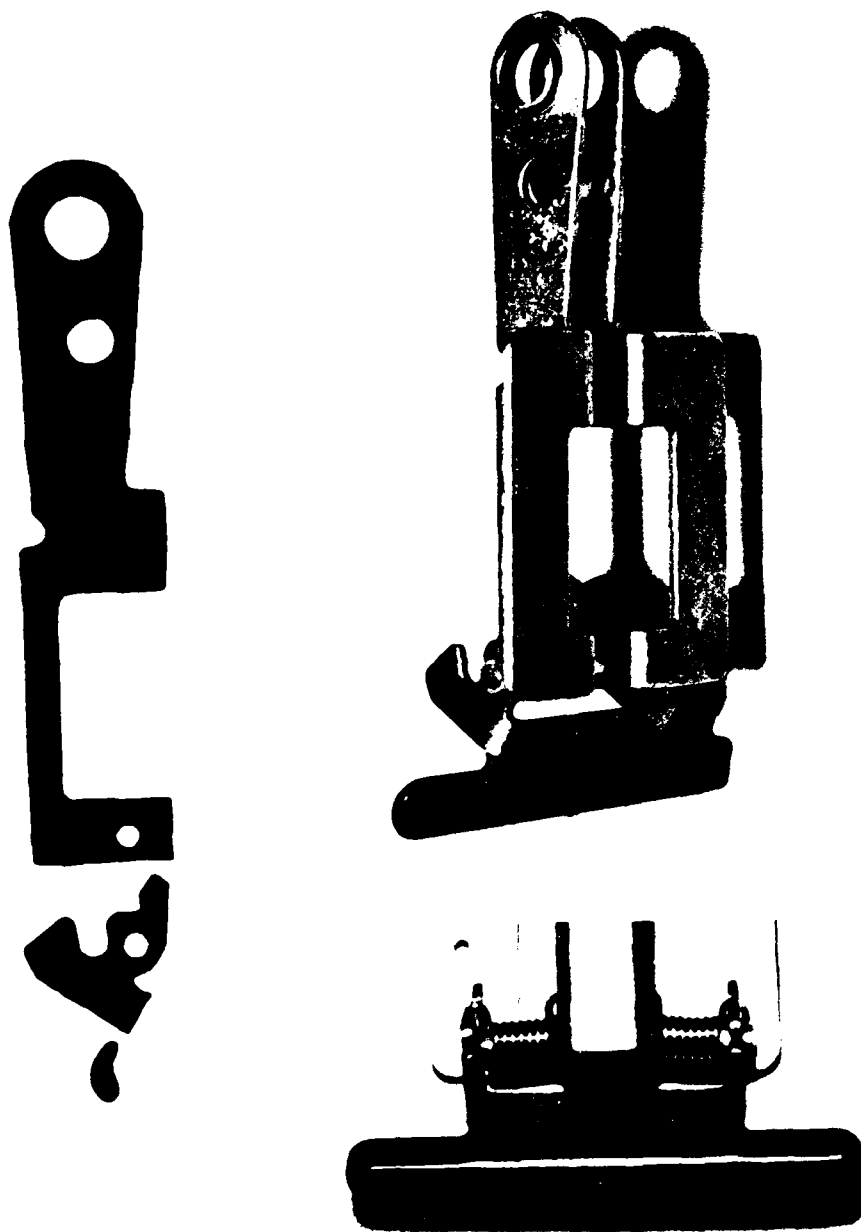


Figure 6. Plastic coated grip

## Environmental Test

Two containers equipped with the improved latches (figs. 5 and 6) were subjected to the stresses anticipated in the field environment of the Copperhead round. These stresses represent transportation of the M712 projectile from the depot to the howitzer company.

The test sequence selected was taken from the quality specifications set by the Army on the Copperhead system. Requisition procedures require that four sample containers must undergo a first article test before container production is started. Once production is geared-up, a less stringent, monthly lot acceptance test is performed on sample containers. The round itself is regularly containerized, subjected to the environment, and then ballistically fired to ensure quality.

No new containers were available to prove-out the latch. Containers that previously had been vibrated with live ballistic samples in them were used. Finding containers in fair condition was difficult. It was necessary to cannibalize the lower half of one used container with the upper half of another in order to produce one of the samples for this test. No repairs were made. The original gaskets were wiped off with a rag. The baseline latches were removed and the prototype latches installed. The improved latch (fig. 5) was snapped into all cages except one at each end of each container. The latch with the plastisol grip (fig. 6) was installed inside these cages because the environment was considered most severe at the ends of the container.

Each container was laden with an inert training round. The latches were adjusted to a pull force typical of production (between 25 and 35 lb). The containers were then pressurized and emersed in water (fig. 16). No bubbles emanated anywhere.

The containers were then subjected to the equivalent of a first article test with the following exceptions:

- First article samples are generally built just for that purpose. The test samples for the latch prove-out were random samples, two years apart in production, and already subject to vibration once before.
- Only two sample containers were used instead of four.
- The salt spray test was deleted. The new latches had the same cadmium plating as the baseline latch. This plating had already been proven satisfactory in a previous first article test.
- The handle pull test was deleted. These handles are called suitcase or bail type or chest handles and are a part of the weldment. The latches are independent of these handles and have no effect on their condition.

Three types of stresses were applied: transportation vibration, loose cargo bounce, and drop. The laden containers were rigidly clamped to a platform (fig. 17). They were vibrated from 2-1/2 to 3-1/2 g's, from 5 to 200 cycles per second, and for a total of 4 hours. Following that, each container was fenced in on

a platform which was vibrating at 284 cycles per minute, displacing one inch during vibration, and for a duration of one-half hour. Finally, each container was dropped on each corner from a height of two feet.

Another leak test indicated that both containers were still sealed.

One container was opened as required by the inspection plan. The drop test had caused the channels on the ends of both containers to be dented inward. This damage reduced the clearance between the lock grip and the bottom of the channel. There was some difficulty in sliding one's hand under the latches located at the ends of the container. Personnel performing the inspections were able to reach the ears of the lock from above. All latches opened without the use of a tool. The dummy round was removed, and the weldment inspected for cracks. No damage was found on the round or the inside of the container. The round was repacked and the container was leak tested again to verify the seal.

Each laden container was then clamped to the platform of a shock machine and subjected to 200 g's for 10 ms. This test was similar to the preliminary shock test except that complete laden containers were shocked instead. The shock was repeated three times on each of the six faces of each container. A container mounted in two orientations is shown in figures 18 and 19, respectively. The severity of this test can be appreciated by considering that the container weighs 60 lb and the round weighs 140 lb.

The leak test indicated no leaks along either of the two gaskets. A fine stream of bubbles emanated from one cover. The leak came from a weld which held an aluminum block to the inside for the clam shell lid. This block braces a yoke where the round is nested. Apparently, the shock had caused the round to move inside the container and tear the weld. This damage was normally considered a defect and a failure of the container.

Each latch was opened and then closed; first manually and then with a spring scale. The pull force on each latch was measured with the other latches closed making the pull force independent of the unlatching sequence. Most latches required from 20 to 30 lb of pull to open them; four latches opened between 15 and 17 lb, and one latch required 40 lb.

A weld crack was discovered inside one container where its yoke was welded to the lower half of the clamshell. Small cracks of this type can occur following the shock test and are acceptable within limits permitted by the quality provisions of the baseline.

In summary, two containers equipped with latch prototypes were subjected to a virtual first article test. One container had an acceptable weld crack; the other had an unacceptable weld crack and leaked. This damage was not attributable to the latches. It should also be remembered that these containers were not in optimum condition before the test. They had a vibration history and their gaskets had been stored under compression for years.

Personnel at White Sands who regularly perform ballistic firings believe that the new latch is an improvement over the existing one. The dual springs and longer fingerholds increase security and at the same time facilitate easier opening.

Incidental to this test sequence, but nevertheless significant, is evidence of the quality of containers that have gone into stockpile. The two containers subjected to the first article test were a very small sample from thousands of units manufactured by Lanson Industries. However, they indicate that Lanson has been conscientious and has maintained care in their operation. Furthermore, confidence in the baseline has been reaffirmed. It has been demonstrated again that containers built to those drawings can survive the prescribed testing.

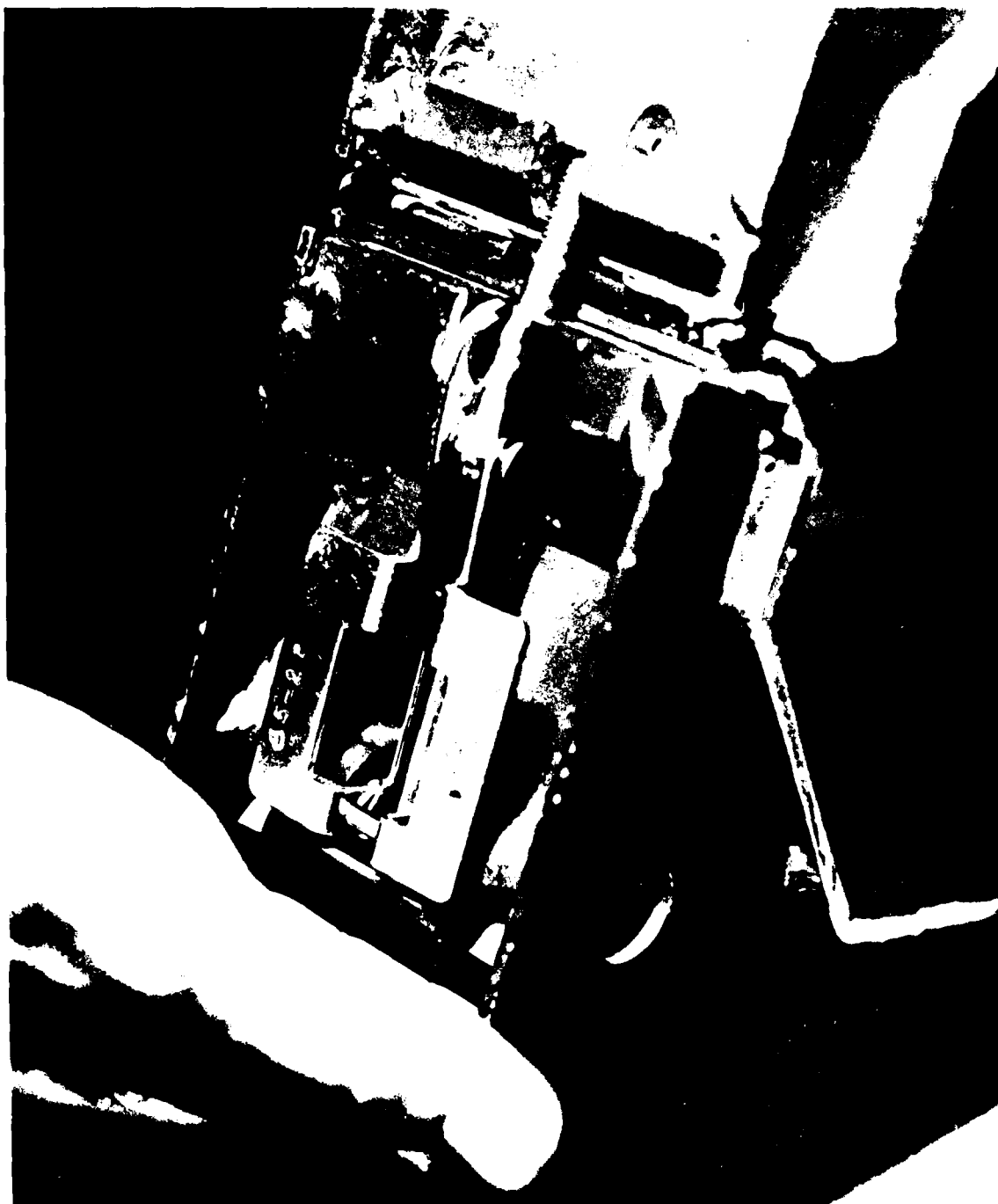


Figure 7. Four finger grasp



Figure 8. Lid release



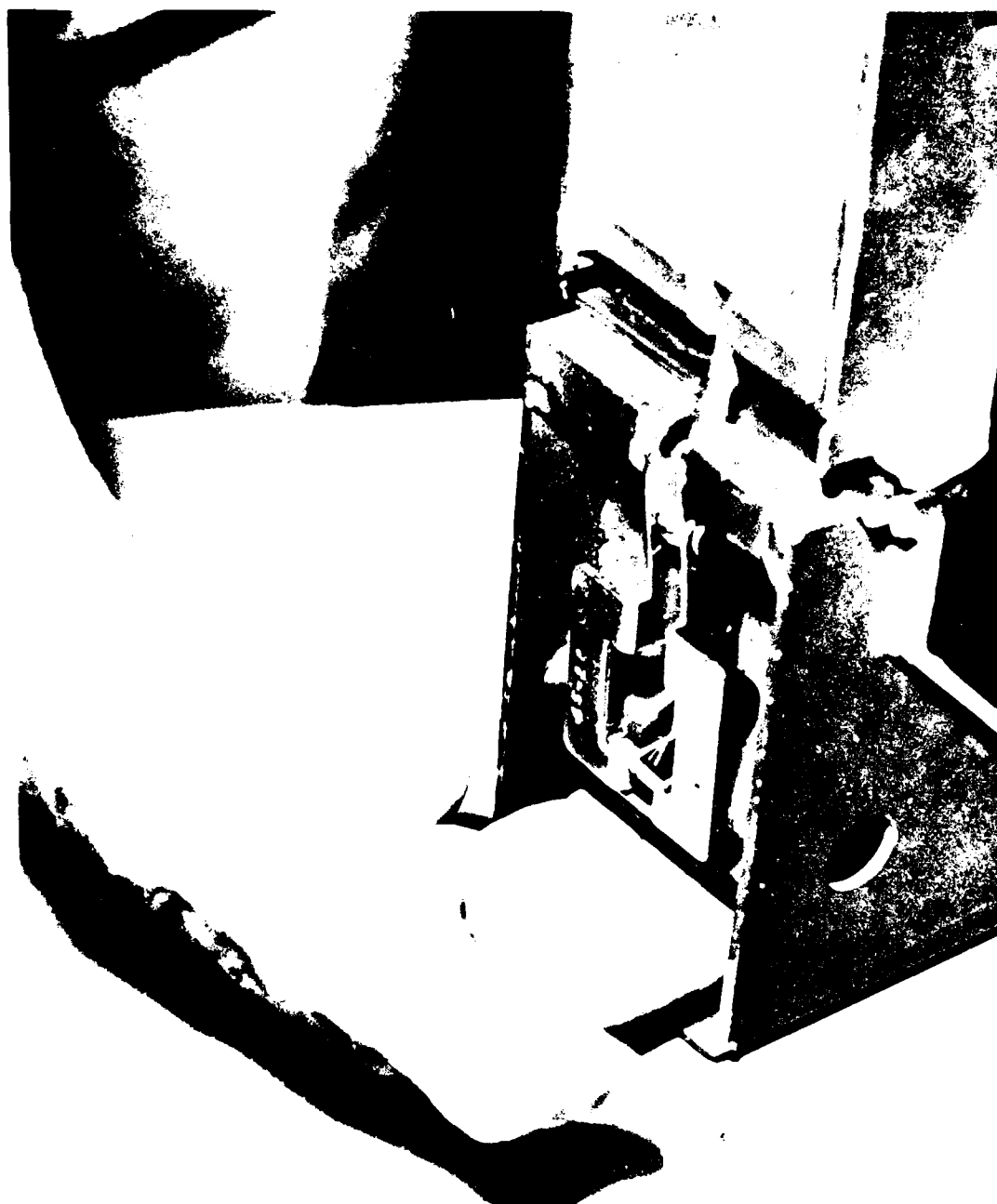
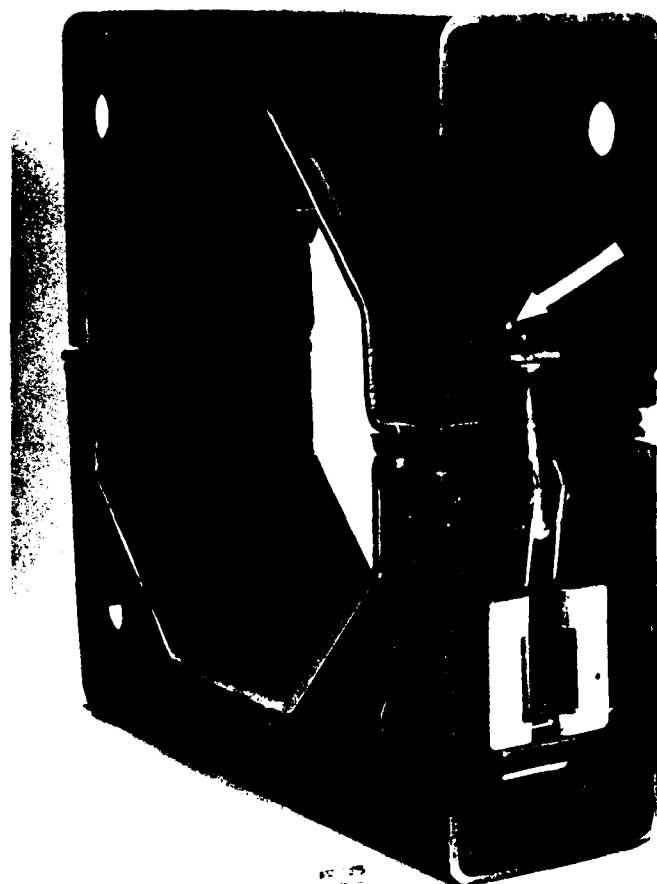


Figure 9. Three finger grasp. (This individual had a broad build and preferred using three fingers. However, he was able to get four fingers between the ears of the lock.)



drive pin

Figure 10. Sawed-off bulkhead from the Copperhead container [The baseline latch is installed on the near side of the bulkhead. The T-bolt is assembled with a clevis pin but the drive pin can be used instead. Early in production it was discovered that a T-bolt that was too long interfered with the opening. Threads protruding beyond the top of the barrel nut engraved the strike (arrow).]

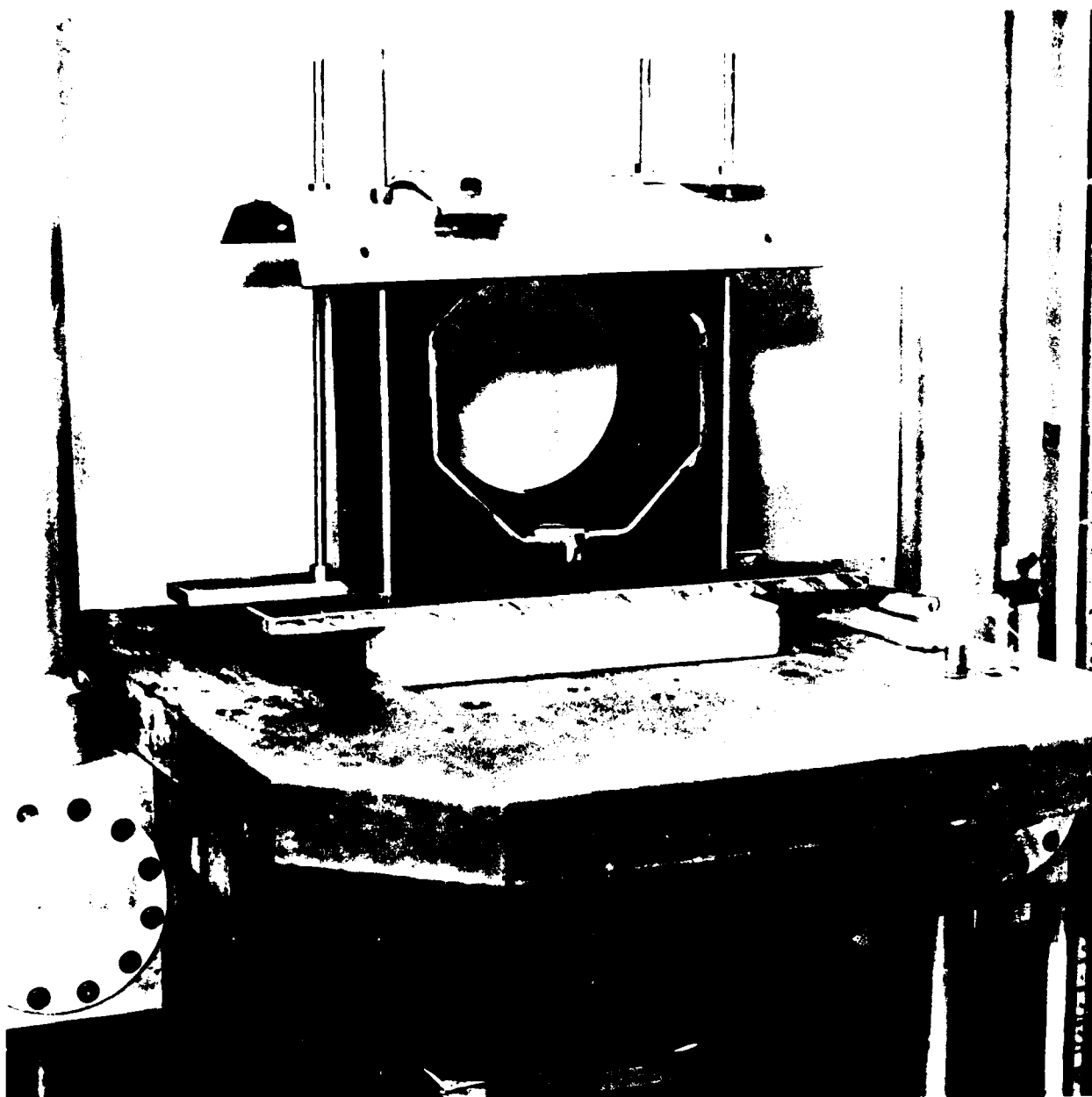


Figure 11. A bulkhead bolted to the platform of a shock machine. (The bulkhead was blocked up to allow access to the latch on the bottom.)

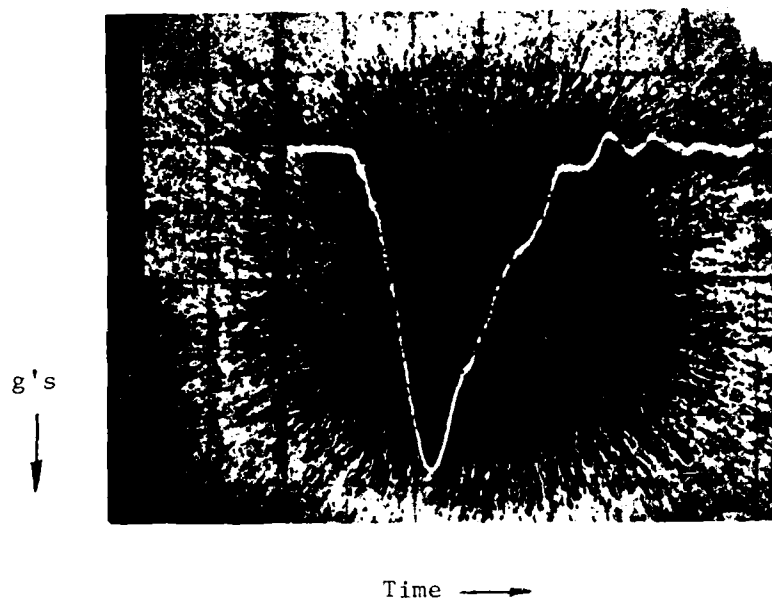
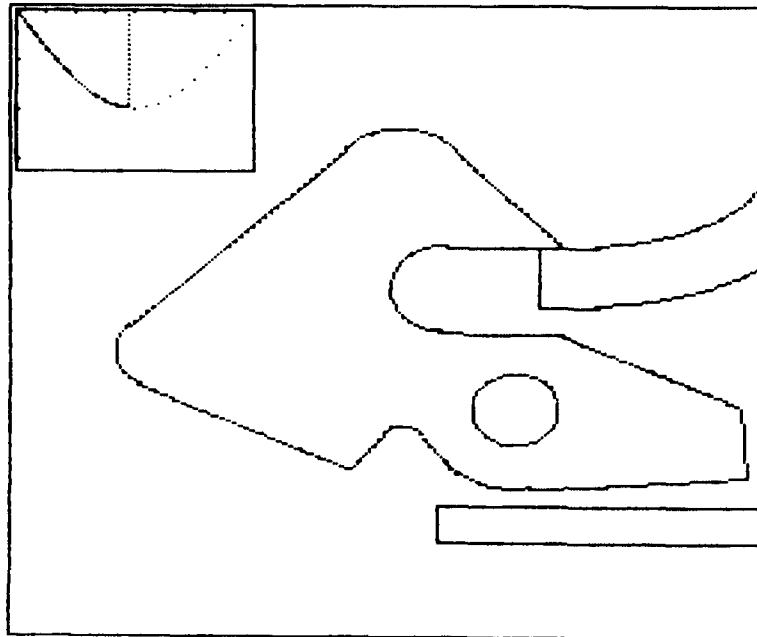


Figure 12. Shock pulse from the transducer screwed to the top of the table  
(trace interpreted as 250 g's for 7 ms)

Baseline latch, handle initially INBOARD



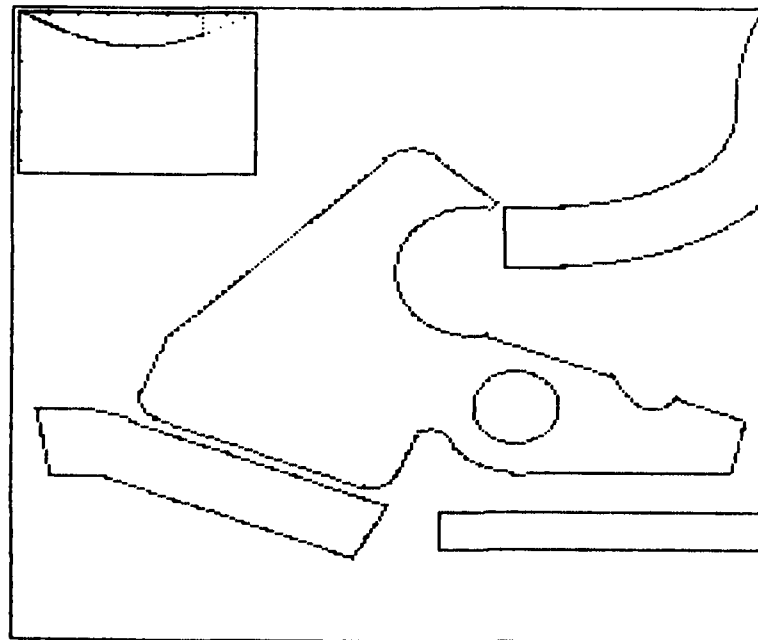
Shock peaks at  
200 G's

8 milli-  
second duration

3.85 ms, 200 G's  
indicated

Figure 13. The baseline latch halfway through a shock pulse (The lock has stopped rotating and is starting to close. Friction of the tooth against the cage plate was included in the simulation in order to get the calculated g threshold to agree with the test. The Rexnord lock has sharply pointed steel teeth which engrave the soft aluminum cage plate. This simulation can also show that the baseline latch will fly open under a much milder jolt if restraining friction is neglected.)

Heavy gripper plate, handle initially INBOARD



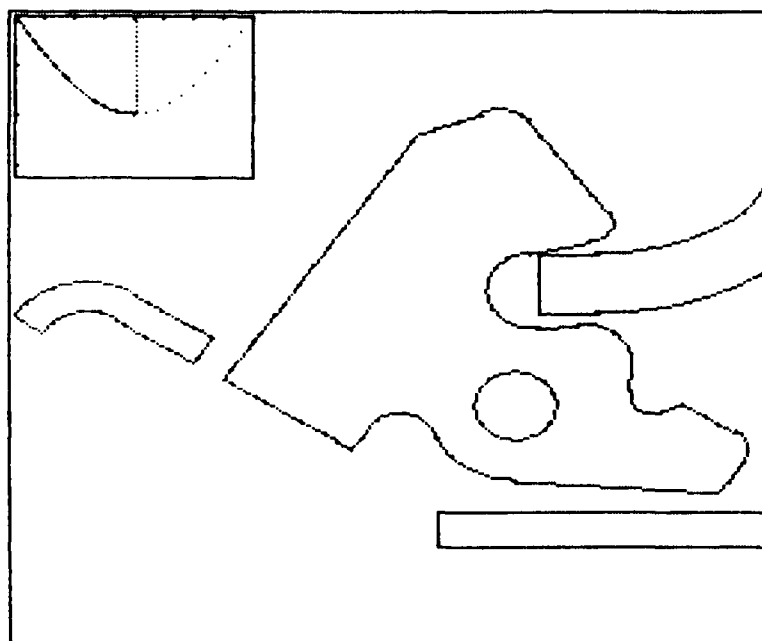
Shock peaks at  
70 G's

8 milli-  
second duration

6.23 ms, 45 G's  
indicated

Figure 14. Heavy gripper plate during a mild shock (Following impact of the teeth on the cage plate the lock continues to move downward and causes the teeth to slide off. No friction is assumed. The springs have finally stopped the rotation of the lock and the lock begins to snap shut. However, the handle has already started to move downward again.

Improved latch, handle initially INBOARD



Shock peaks at  
200 G's

8 milli-  
second duration

4.10 ms, 200 G's  
indicated

Figure 15. Improved latch during a substantial g shock (No restraining friction from sliding or impact is assumed. The springs have arrested the rotation of the lock and the lock begins to reset.)

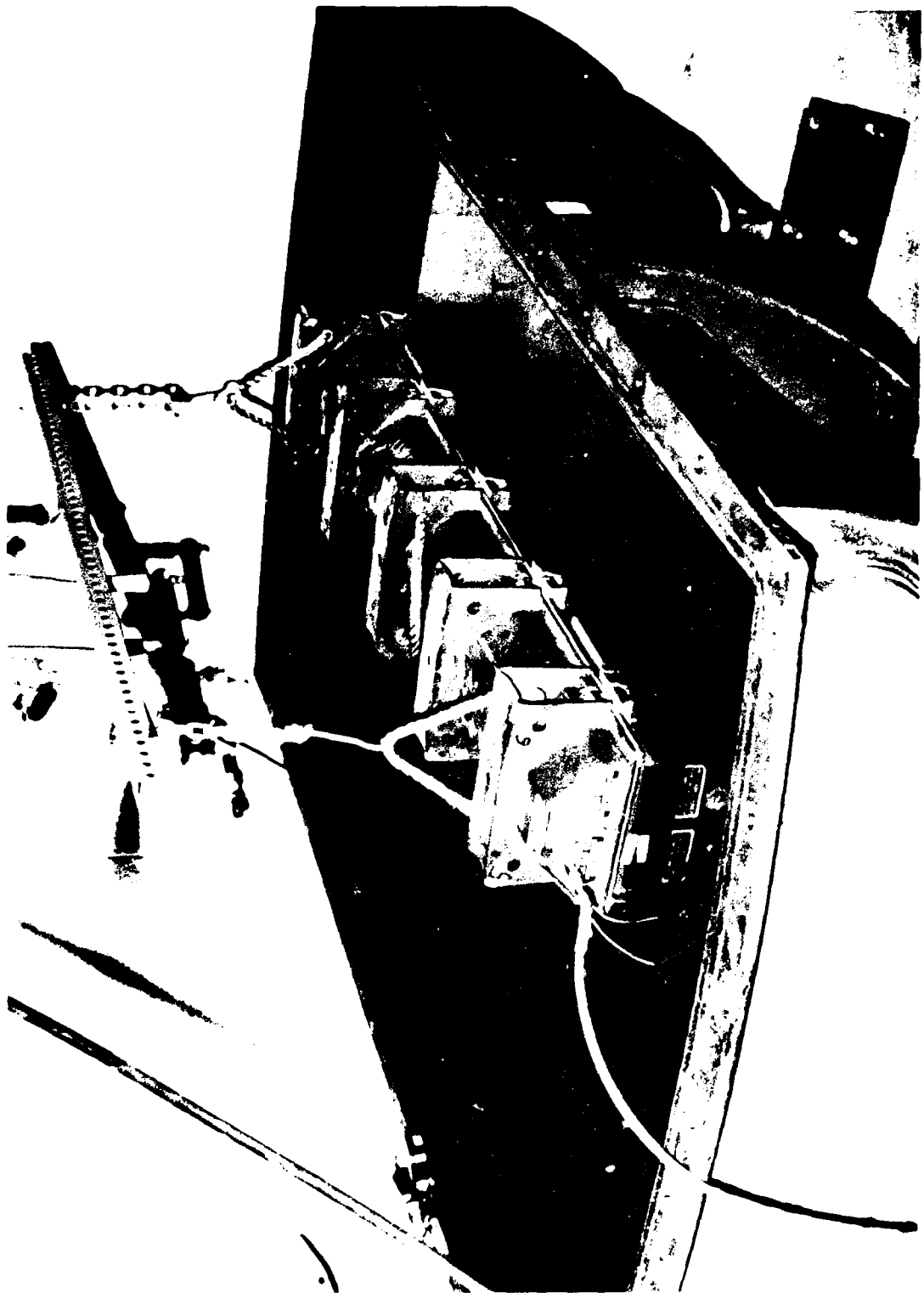


Figure 16. Pressure leak test



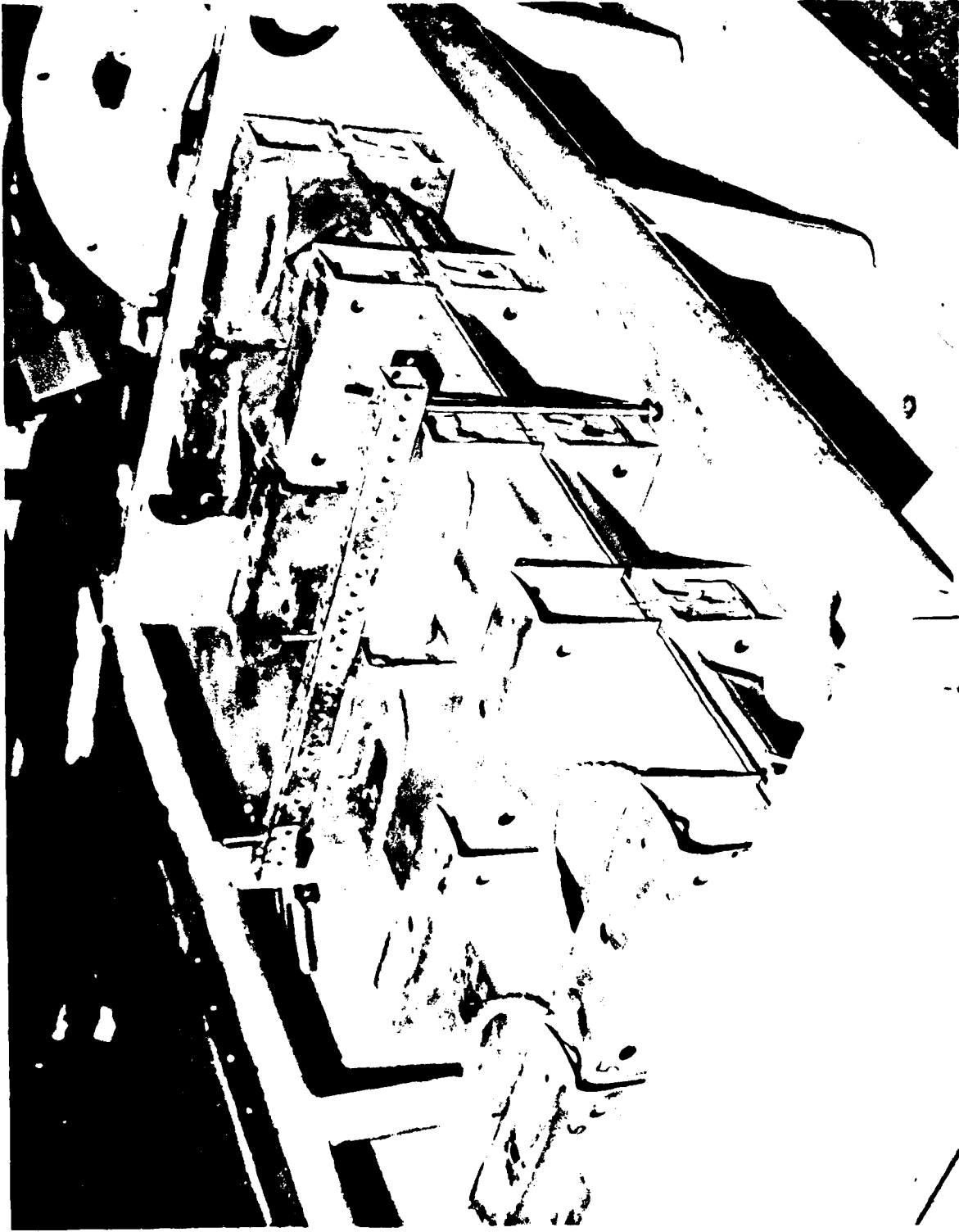


Figure 17. Transportation vibration environment

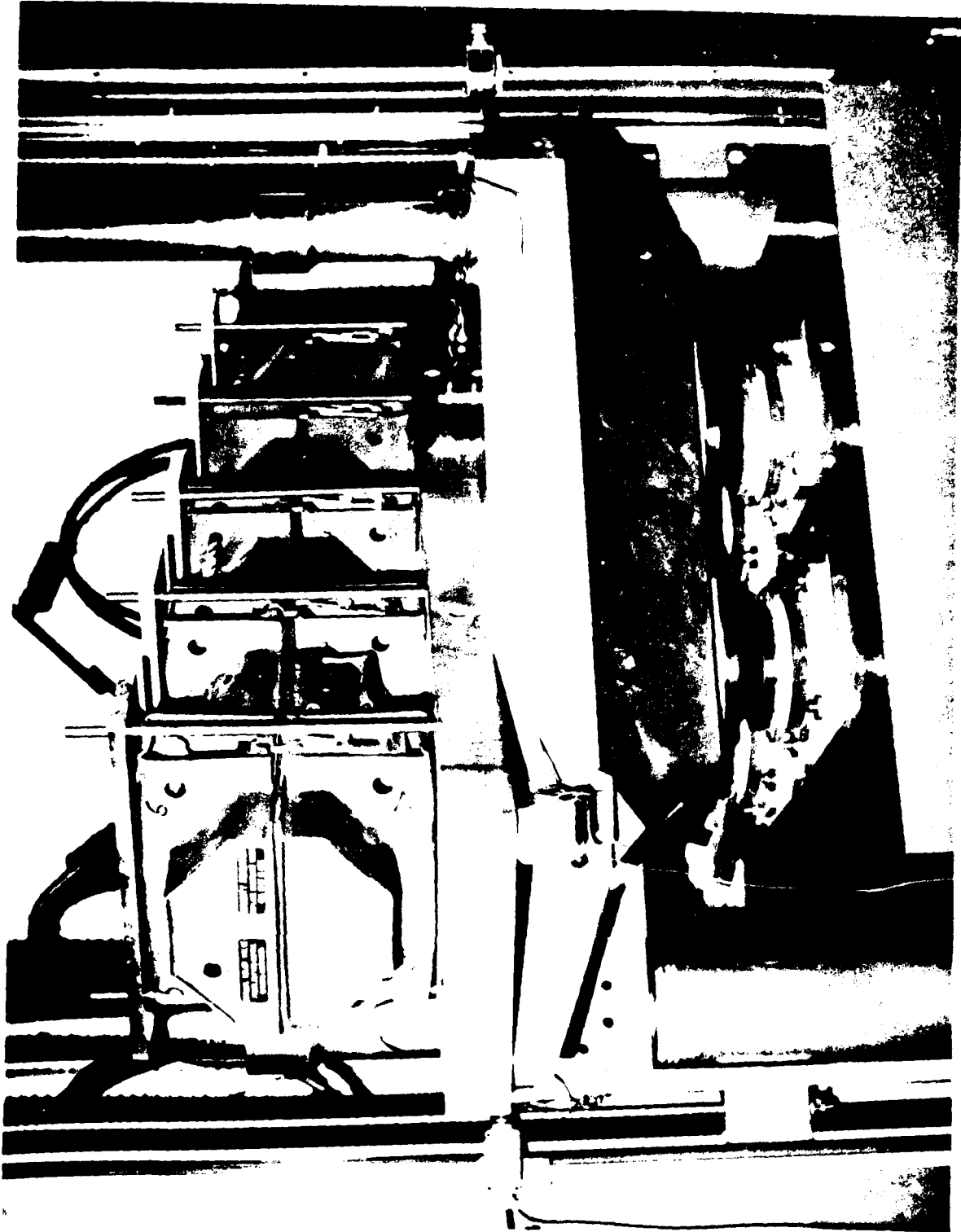


Figure 18. Vertical axis fragility shock

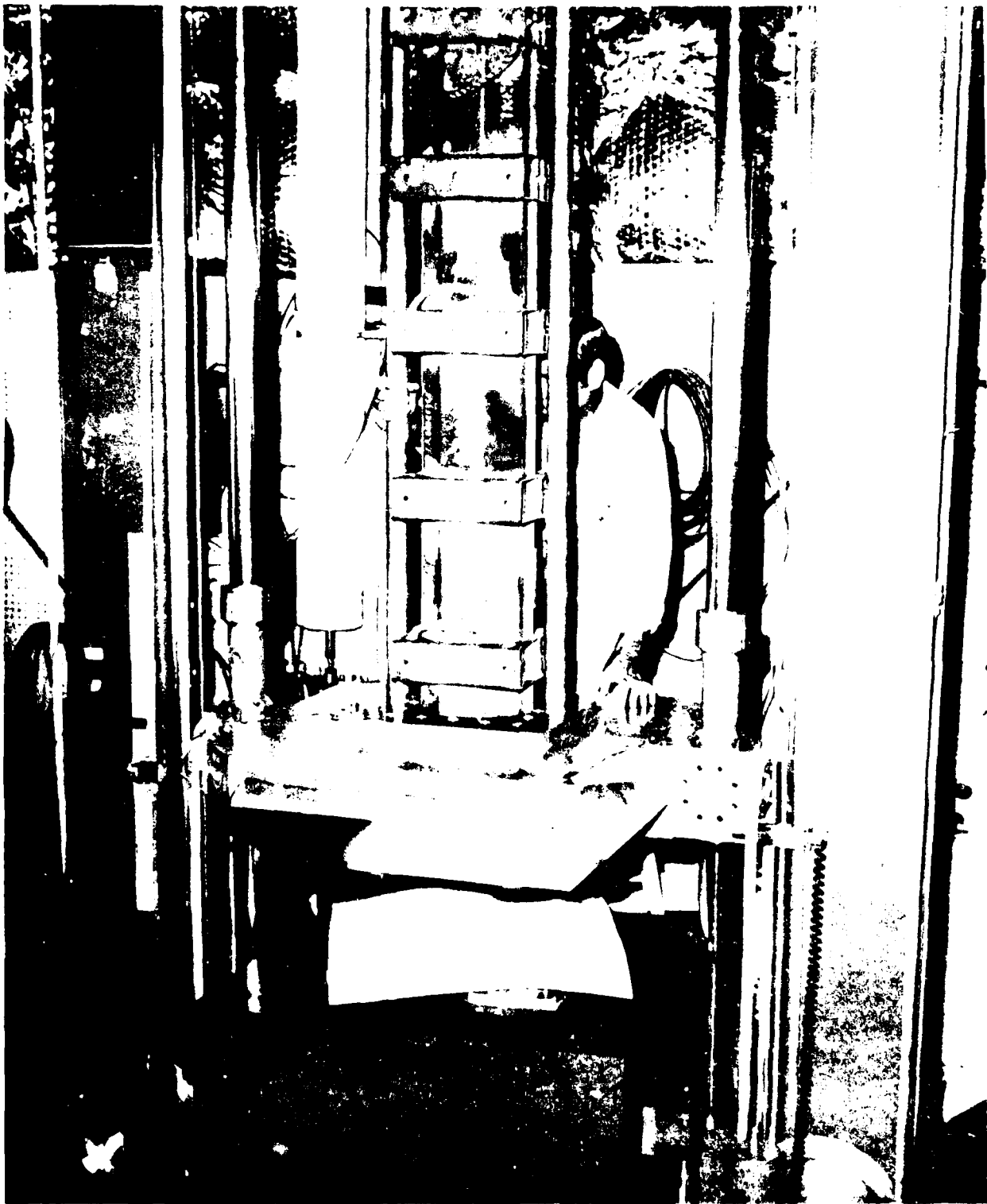


Figure 19. Longitudinal axis fragility (a)

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